# CERTIFICATE OF TRANSLATION

**Re: Taiwanese Patent Application No. 91121424, Filed on September 19, 2002.**

**I, Yu-Ying Liang of TOP TEAM INTERNATIONAL PATENT & TRADEMARK OFFICE located at 3rd Fl., No.279, Sec.4, Hsin-Yi Rd., Taipei, Taiwan, R.O.C., hereby declare that I am the translator of the document attached and certify that the following is a true and accurate translation of the priority document to the best of my knowledge and belief.**

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**Yu-Ying Liang**

**Dated this 27th day of September, 2006**

TITLE

# TRANSFLECTIVE LIQUID CRYSTAL DISPLAY STRUCTURE

## ABSTRACT OF THE DISCLOSURE

A transflective LCD device. A first color filter is on a first substrate, and a reflective electrode is on the first color filter. The reflective electrode has an opaque portion and a transparent portion. A second color filter is formed on an inner side of a second substrate opposite the first substrate. A common electrode is on the second color filter, and a liquid crystal layer is between the first and the second substrates. Another transflective LCD device is provided, including a first color filter on a first substrate, a second color filter on the first color filter, wherein a reflective layer is interposed between the first and second color filters.

## BACKGROUND OF THE INVENTION

### Field of the Invention

The present invention relates to a structure of a transflective liquid crystal display device, and more particularly, to a transflective liquid crystal display device with balanced color purity in both transmissive and reflective modes.

### Description of the Related Art

Reflective liquid crystal display devices are classified into two types. One is a total reflective type liquid crystal display device, and another is a transflective type liquid crystal display device. The total reflective type liquid crystal display device uses reflections from external light sources instead back light as light sources. The total reflective type LCD has an advantage of low power assumption, but cannot be seen by one's eye and has low contrast in a dark environment. Typically, front light source is used for an auxiliary light source for the total reflective type liquid crystal display device.

A transflective LCD device can operate as both a reflective and transmission type LCD. When environment light source is enough, the transflective LCD device does not require a backlight. In contrast, when no external light is available, the transflective LCD device uses backlight. Transflective LCDs device have advantages of low power assumption and is workable in a dark environment. Consequently, transflective LCDs are widely used in cell phones and personal digital assistants (PDA).

Fig. 1 is a sectional view of a conventional transflective LCD device. As shown in Fig. 1, the conventional transflective LCD device includes a lower substrate 100. The lower substrate 100 has an insulating layer 110 and a reflective electrode 120 formed thereon, wherein the reflective electrode 120 has an opaque portion 122 and a transparent portion 124. The opaque portion 122 of the reflective electrode 120 can be an aluminum layer and the transparent portion 124 of the reflective electrode 120 can be an ITO (indium tin oxide) layer. An upper substrate 160 is opposite to the lower substrate 100. A color filter 150 is disposed on the inner surface of the upper substrate 160 and a common electrode 140 is on the color filter 150. A liquid crystal layer 130 is interposed between the upper substrate 160 and the lower substrate 100.

The conventional transflective LCD device, however, has a problem of different color reproduction levels (color purity) in reflective and transmissive modes, due to, referring to Fig. 1, the backlight 180 penetrating the transparent portion 124 through the color filter 150 once and the ambient light 170 reflected from the opaque portion 122 passes through the color filter 150 twice. This degrades the display quality of transflective LCDs greatly.

## SUMMARY OF THE INVENTION

Therefore, an object of the invention is to provide a structure of a liquid crystal device.

Another object of the present invention is to provide a transflective liquid crystal display device with balanced color purity in both transmissive and reflective modes.

In order to achieve these objects, the present invention provides a transflective liquid crystal display device. A first substrate and a second substrate opposite thereto are provided. A first color filter is formed on the first substrate. A reflective electrode is formed on the first color filter, wherein the reflective electrode has at least one opaque portion and at least one transparent portion. A second color filter is formed on an inner side of the second substrate. A common electrode on the second color filter. A liquid crystal layer is interposed between the first substrate and the second substrate.

The present invention also provides another transflective liquid crystal display device. A first substrate and a second substrate opposite thereto are provided. A first color filter is formed on the first substrate. A reflective layer is formed on part of the first color filter. A second color filter is formed on the reflective layer and the first color filter. A transparent electrode is formed on the second color filter. A common electrode is formed on an inner side of the second substrate. A liquid crystal layer is interposed between the first substrate and the second substrate.

## BRIEF DESCRIPTION OF THE DRAWINGS

The present invention can be more fully understood by reading the subsequent detailed description in conjunction with the examples and references made to the accompanying drawings, wherein:

Fig. 1 is a sectional view according to a conventional transflective LCD device;

Fig. 2 is a sectional view according to a first embodiment of the present invention;

Fig. 3 is a sectional view according to a second embodiment of the present invention;

Fig. 4 is a sectional view according to a third embodiment of the present invention;

Fig. 5 is a sectional view according to a fourth embodiment of the present invention;

Fig. 6 is a sectional view according to a fifth embodiment of the present invention;

Fig. 7 is a sectional view according to a sixth embodiment of the present invention;

Fig. 8 is a sectional view according to a seventh embodiment of the present invention; and

Fig. 9 is a sectional view according to an eighth embodiment of the present invention.

## SYMBOLS

**Prior art**

100~lower substrate;

110~insulating layer;

120~reflective electrode;

122~opaque portion;

124~transparent portion;

130~liquid crystal layer;

140~common electrode;

150~color filter;

160~upper substrate;

170~ambient light;

180~ backlight.

**The invention**

200, 300, 400, 500, 600, 700, 800, 900~first substrate;

210, 310, 410, 510, 610, 710, 810, 910~first color filter;

220, 320, 420, 520, 620~insulating layer;

322, 512, 932~opening;

230, 330, 430, 530, 630, 720~reflective electrode;

820, 920~reflective layer;

232, 332, 432, 532, 632, 722~opaque portion;

234, 334, 434, 534, 634, 724~transparent portion;

824, 924~ portion without reflective layer;

236, 336, 436, 536, 636, 726, 822, 922~ambient light;

238, 338, 438, 538, 638, 728, 826, 926~backlight;

840, 940~transparent electrode;

240, 340, 440, 540, 640, 740, 850, 950~liquid crystal layer;

250, 350, 450, 550, 650, 750, 860, 960~common electrode;

260, 360, 460, 560, 660, 760, 830, 930~second color filter;

270, 370, 470, 570, 670, 770, 870, 970~second substrate.

## DETAILED DESCRIPTION OF THE INVENTION

### First Embodiment

Fig. 2 is a sectional view according to a first embodiment of the present invention.

In Fig. 2, a first substrate 200 is provided. The first substrate 200 can be a glass substrate comprising a thin film transistor (TFT) array. Then, a first color filter 210 is formed on the first substrate 200. An insulating layer 220 is formed on the first color filter 210. Next, a reflective electrode 230 is formed on the insulating layer 220, wherein the reflective electrode 230 has at least one opaque portion 232 and at least one transparent portion 234. The opaque portion 232 reflects ambient light 236, and backlight 238 pass through the transparent portion 234. The opaque portion 232 of the reflective electrode 230 reflects the ambient light 236. The backlight 238 passes through the transparent portion 234. The first color filter 210 may have three color regions, such as red (R), green (G), and blue (B). The opaque portion 232 of the reflective electrode 230 can be an aluminum layer having an uneven surface. The transparent portion 234 of the reflective electrode 230 can be an ITO (indium tin oxide).

In Fig. 2, a second color filter 260 is formed on an inner side of a second substrate 270 opposite the first substrate 200. A common electrode 250 is then formed on the second color filter 260. Next, liquid crystal material is filled into a space between the common electrode 250 and the reflective electrode 230 to form a liquid crystal layer 240. The second substrate 270 can be a glass substrate. The second color filter 260 may have three

color regions, such as red (R), green (G), and blue (B). The common electrode can be ITO.

Still referring to Fig. 2, the backlight 238 penetrating the transparent portion 234 passes through the first color filter 210 once and the second color filter 260 once. The ambient light 236 reflected from the opaque portion 232 passes through the second color filter 260 twice. Thus, the number of passages of the backlight 238 and the ambient light 236 through the color filter are the same, twice, thereby normalizing color reproduction (color purity) between reflective and transmissive modes of the transflective LCD of the first embodiment.

**Second Embodiment**

Fig. 3 is a sectional view according to a second embodiment of the present invention.

In Fig. 3, a first substrate 300 is provided. The first substrate 300 can be a glass substrate comprising a thin film transistor (TFT) array. Then, a first color filter 310 is formed on the first substrate 300. An insulating layer 320 is formed on the first color filter 310. Then, part of the insulating layer 320 is removed to form at least one opening 322 in the insulating layer 320. A reflective electrode 330 is then formed on the insulating layer 320 and on the sidewall and bottom of the opening 322. The reflective electrode 330 has at least one opaque portion 332 and at least one transparent portion 334, wherein the transparent portion 334 is located in the opening 322. The opaque portion 332 of the reflective electrode 330 reflects the ambient light 336. The backlight 338 passes through the transparent portion 334. The first color filter 310 may have three color regions, such as red (R), green (G), and blue (B).

The opaque portion 332 of the reflective electrode 330 can be an aluminum layer having an uneven surface. The transparent portion 334 of the reflective electrode 330 can be an ITO layer.

In Fig. 3, a second color filter 360 is formed on an inner side of the second substrate 370. Then, a common electrode 350 is formed on the second color filter 360. Next, liquid crystal material is filled into a space between the common electrode 350 and the reflective electrode 330 to form a liquid crystal layer 340. The second substrate 370 can be a glass substrate. The second color filter 360 may have three color regions, such as red (R), green (G), and blue (B). The common electrode 350 can be an ITO layer.

Still referring to Fig. 3, the backlight 338 penetrating the transparent portion 334 passes through the first color filter 310 once and the second color filter 360 once. The ambient light 336 reflected from the opaque portion 332 passes through the second color filter 360 twice. Thus, the number of passages of the backlight 338 and the ambient light 336 through the color filter are the same, twice, thereby normalizing color reproduction (color purity) between reflective and transmissive modes of the transflective LCD of the second embodiment.

**Third Embodiment**

Fig. 4 is a sectional view according to a third embodiment of the present invention.

In Fig. 4, a first substrate 400 is provided. The first substrate 400 can be a glass substrate comprising a thin film transistor (TFT) array and the second substrate 470 can be a

glass substrate. Then, a first color filter 410 is formed on the first substrate 400. An insulating layer 420 with bumps is formed on part of the first color filter 410. Then, a reflective electrode 430 is formed on the first color filter 410 and the insulating layer 420, wherein the reflective electrode 430 has at least one opaque portion 432 and at least one transparent portion 434. The opaque portion 432 of the reflective electrode 430 reflects the ambient light 436. The backlight 438 passes through the transparent portion 434. The first color filter 410 may have three color regions, such as red (R), green (G), and blue (B). The opaque portion 432 of the reflective electrode 430 can be an aluminum layer having an uneven surface. The transparent portion 434 of the reflective electrode 430 can be an ITO.

Still referring to Fig. 4, a second color filter 460 is formed on an inner side of a second substrate 470. Then, a common electrode 450 is formed on the second color filter 460. Next, liquid crystal material is filled into a space between the common electrode 450 and the reflective electrode 430 to form a liquid crystal layer 440. The second substrate 470 can be a glass substrate. The second color filter 460 may have three color regions, such as red (R), green (G), and blue (B).

As shown in Fig. 4, the backlight 438 penetrating the transparent portion 434 passes through the first color filter 410 once and the second color filter 460 once. The ambient light 436 reflected from the opaque portion 432 passes through the second color filter 460 twice. Thus, the number of passages of the backlight 438 and the ambient light 436 through the color

filter are the same, twice, thereby normalizing color reproduction (color purity) between reflective and transmissive modes of the transflective LCD of the third embodiment.

**Fourth Embodiment**

Fig. 5 is a sectional view according to a fourth embodiment of the present invention.

In Fig. 5, a first substrate 500 is provided. The first substrate 500 can be a glass substrate comprising a thin film transistor (TFT) array and the second substrate 570 can be a glass substrate. Then, a first color filter 510 is formed on the first substrate 500. An insulating layer 520 with bumps is then formed on part of the first color filter 510. At least one opening 512 is formed in the first color filter 510. A reflective electrode 530 is formed on the insulating layer 520 and on the sidewall and the bottom of the opening 512. The reflective electrode 530 has at least one opaque portion 532 and at least one transparent portion 534, wherein the transparent portion 534 is located in the opening 512. The opaque portion 532 of the reflective electrode 530 reflects the ambient light 536. The backlight 538 passes through the transparent portion 534. The first color filter 510 may have three color regions, such as red (R), green (G), and blue (B). The opaque portion 532 of the reflective electrode 530 can be an aluminum layer having an uneven surface. The transparent portion 534 of the reflective electrode 530 can be an ITO layer.

In Fig. 5, a second color filter 560 is formed on an inner side of a second substrate 570 opposite the first substrate 500. Then, a common electrode 550 is formed on the second color filter

560. Next, liquid crystal material is filled into a space between the common electrode 550 and the reflective electrode 530 to form a liquid crystal layer 540. The second substrate 570 can be a glass substrate. The second color filter 560 may have three color regions, such as red (R), green (G), and blue (B). The common electrode 550 can be an ITO layer.

As shown in Fig. 5, the backlight 538 penetrating the transparent portion 534 passes through the first color filter 510 once and the second color filter 560 once. The ambient light 536 reflected from the opaque portion 532 passes through the second color filter 560 twice. Thus, the number of passages of the backlight 538 and the ambient light 536 through the color filter are the same, twice, thereby normalizing color reproduction (color purity) between reflective and transmissive modes of the transflective LCD of the fourth embodiment.

**Fifth Embodiment**

Fig. 6 is a sectional view according to a fifth embodiment of the present invention.

In Fig. 6, a first substrate 600 is provided. The first substrate 600 can be a TFT array glass substrate. Then, a first color filter 610 is formed on the first substrate 600. An insulating layer 620 is formed on the first color filter 610. Then, a reflective electrode 630 is formed on the insulating layer 620, wherein the reflective electrode 630 has at least one opaque portion 632 and at least one transparent portion 634. The first color filter 610 may have three color regions, such as red (R), green (G), and blue (B). Further, in this embodiment, the first color filter 610 can be formed with a portion thereof

having bumps using patterning process. The opaque portion 632 of the reflective electrode 630 can be an aluminum layer having an uneven surface. The transparent portion 634 of the reflective electrode 630 can be an ITO layer.

In Fig. 6, a second color filter 660 is formed on an inner side of a second substrate 670 opposite the first substrate 600. Then, a common electrode 650 is formed on the second color filter 660. Next, liquid crystal material is filled into a space between the common electrode 650 and the reflective electrode 630 to form a liquid crystal layer 640. The second substrate 670 can be a glass substrate. The second color filter 660 may have three color regions, such as red (R), green (G), and blue (B). The common electrode 650 can be an ITO layer.

As shown in Fig. 6, the backlight 638 penetrating the transparent portion 634 passes through the first color filter 610 once and the second color filter 660 once. The ambient light 636 reflected from the opaque portion 632 passes through the second color filter 660 twice. Thus, the number of passages of the backlight 638 and the ambient light 636 through the color filter are the same, twice, thereby normalizing color reproduction (color purity) between reflective and transmissive modes of the transflective LCD of the fifth embodiment.

**Sixth Embodiment**

Fig. 7 is a sectional view according to a sixth embodiment of the present invention.

In Fig. 7, a first substrate 700 is provided. The first substrate 700 can be a thin film transistor (TFT) array substrate

and the second substrate 770 can be a glass substrate. Then, a first color filter 710 is formed on the first substrate 700. A reflective electrode 720 is formed on the first color filter 710. The reflective electrode 720 has at least one opaque portion 722 and at least one transparent portion 724, wherein the opaque portion 722 reflects ambient light 726, and backlight 728 pass through the transparent portion 724. The first color filter 710 may have three color regions, such as red (R), green (G), and blue (B). Moreover, a patterning process and a thermal flow process are performed, whereby the first color filter 710 whose partial surfaces have bumps is formed. The opaque portion 722 of the reflective electrode 720 can be an aluminum layer having an uneven surface. The transparent portion 724 of the reflective electrode 720 can be an ITO layer.

In Fig. 7, a second color filter 760 is formed on an inner side of a second substrate 770 opposite the first substrate 700. Then, a common electrode 750 is formed on the second color filter 760. Next, liquid crystal material is filled into a space between the common electrode 750 and the reflective electrode 720 to form a liquid crystal layer 740. The second substrate 770 can be a glass substrate. The second color filter 760 may have three color regions, such as red (R), green (G), and blue (B). The common electrode 750 can be an ITO layer.

As shown in Fig. 7, the backlight 728 penetrating the transparent portion 724 passes through the first color filter 710 once and the second color filter 760 once. The ambient light 726 reflected from the opaque portion 722 passes through the second color filter 760 twice. Thus, the number of passages of

the backlight 728 and the ambient light 726 through the color filter are the same, twice, thereby normalizing color reproduction (color purity) between reflective and transmissive modes of the transflective LCD of the sixth embodiment.

**Seventh Embodiment**

Fig. 8 is a sectional view according to a seventh embodiment of the present invention.

In Fig. 8, a first substrate 800 is provided. The first substrate 800 can be a thin film transistor (TFT) array substrate. Then, a first color filter 810 is formed on the first substrate 800. A patterning process and a thermal flow process can be further performed, whereby the first color filter 810 whose partial surfaces have bumps is obtained. The first color filter 810 may have three color regions, such as red (R), green (G), and blue (B). A reflective layer 820 is formed on the bump portion of the first color filter 810. The reflective layer 820 may be an aluminum layer having an uneven surface to reflect ambient light 822. Backlight light 826 can pass a portion of the reflective layer 824 without the reflective layer 820. A second color filter 830 is formed on the reflective layer 820 and the first color filter 810. The second color filter 830 may have three color regions, such as red (R), green (G), and blue (B). Then, a transparent electrode 840 (also called a pixel electrode) is formed on the second color filter 830. The transparent electrode 840 can be an ITO.

In Fig. 8, a common electrode 860, such as an ITO layer, is formed on an inner side of a second substrate 870 opposite the first substrate 800. Then, liquid crystal material is filled

into a space between the common electrode 860 and the transparent electrode 840 to form a liquid crystal layer 850. The common electrode 860 can be an ITO layer, and the second substrate 870 can be a glass substrate.

As shown in Fig. 8, the backlight 826 penetrating the portion 824 passes through the first color filter 810 once and the second color filter 830 once. The ambient light 822 reflected from the reflective layer 820 passes through the second color filter 830 twice. Thus, the number of passages of the backlight 826 and the ambient light 822 through the color filter are the same, twice, thereby normalizing color reproduction (color purity) between reflective and transmissive modes of the transflective LCD of the seventh embodiment.

**Eighth Embodiment**

Fig. 9 is a sectional view according to an eighth embodiment of the present invention.

In Fig. 9, a first substrate 900 is provided. The first substrate 900 can be a thin film transistor (TFT) array substrate. Then, a first color filter 910 is formed on the first substrate 900. A patterning process and a thermal flow process can be further performed, whereby the first color filter 910 whose partial surfaces have bumps is obtained. The first color filter 910 may have three color regions, such as red (R), green (G), and blue (B). A reflective layer 920 is formed on the bump portion of the first color filter 910. The reflective layer 920 may be an aluminum layer having an uneven surface to reflect ambient light 922. Backlight light 926 can pass a portion of the reflective layer 924 without the reflective layer 920. A second

color filter 930 is formed on the reflective layer 920 and the first color filter 910. The second color filter 930 may have three color regions, such as red (R), green (G), and blue (B). Then, part of the second color filter 930 is removed to form at least one opening 932 in the second color filter 930. Then, a transparent electrode 940 (also called a pixel electrode) is then formed on the second color filter 930 and on the sidewall and the bottom of the opening 932. The transparent electrode 940 can be an ITO.

In Fig. 9, a common electrode 960, such as an ITO layer, is formed on an inner side of a second substrate 970 opposite the first substrate 900. The common electrode 960 can be an ITO layer, and the second substrate 970 can be a glass substrate. Next, liquid crystal material is filled into a space between the common electrode 960 and the reflective electrode 940 to form a liquid crystal layer 950.

As shown in Fig. 9, the backlight 926 penetrating the portion 924 passes through the first color filter 910 once and the second color filter 930 once. The ambient light 922 reflected from the reflective layer 920 passes through the second color filter 930 twice. Thus, the number of passages of the backlight 926 and the ambient light 922 through the color filter are the same, twice, thereby normalizing color reproduction (color purity) between reflective and transmissive modes of the transflective LCD of the eighth embodiment.

One structure feature of the present invention is as the following: A first color filter is disposed on a first substrate.

A reflective electrode/layer is disposed on the first color filter, comprising an opaque portion and a transparent portion. A liquid crystal layer is disposed on the reflective electrode/layer. A common electrode is disposed on the liquid crystal layer. A second color filter is disposed on the common electrode. A second substrate is disposed on the second color filter.

Another structure feature of the present invention is as following: A first color filter is formed on a first substrate. A second color filter is formed on a first color filter. A reflective layer is interposed a portion between first color filter and the second color filter.

Thus, the number of passages of the backlight and the ambient light through the color filter are the same, twice, thereby normalizing color reproduction (color purity) between reflective and transmissive modes of the transflective LCDs.

Finally, while the invention has been described by way of example and in terms of the above, it is to be understood that the invention is not limited to the disclosed embodiments. On the contrary, it is intended to cover various modifications and similar arrangements as would be apparent to those skilled in the art. Therefore, the scope of the appended claims should be accorded the broadest interpretation so as to encompass all such modifications and similar arrangements.

**What Is Claimed Is:**

1. A transflective liquid crystal display device, comprising:

a first substrate;

a first color filter on the first substrate;

a reflective electrode on the first color filter, wherein the reflective electrode has at least one opaque portion and at least one transparent portion;

a second substrate opposite the first substrate;

a second color filter on an inner side of the second substrate;

a common electrode on the second color filter; and

a liquid crystal layer between the first substrate and the second substrate.

2. The transflective LCD device according to claim 1, further comprising:

an insulating layer formed between the first color filter and the reflective electrode.

3. The transflective LCD device according to claim 1, wherein the first substrate is a substrate comprising a thin film transistor (TFT) array.

4. The transflective LCD device according to claim 1, wherein the opaque portion of the reflective electrode is an aluminum layer having an uneven surface.

5. The transflective LCD device according to claim 1, wherein the transparent portion of the reflective electrode is an ITO (indium tin oxide) layer.

6. The transflective LCD device according to claim 1, wherein partial surfaces of the first color filter have bumps.

7. A transflective liquid crystal display device, comprising:

a first substrate;

a first color filter on the first substrate;

a reflective layer on part of the first color filter;

a second color filter on the reflective layer and the first color filter;

a second substrate opposite the first substrate;a transparent electrode on the second color filter;

a common electrode on an inner side of the second substrate; and

a liquid crystal layer between the first substrate and the second substrate.

8. The transflective LCD device according to claim 7, wherein the first substrate is a substrate comprising a thin film transistor (TFT) array.

9. The transflective LCD device according to claim 7, wherein the reflective layer is an aluminum layer having an uneven surface.

10. The transflective LCD device according to claim 7, wherein the transparent portion of the transparent electrode is an ITO (indium tin oxide) layer.

11. The transflective LCD device according to claim 7, wherein partial surfaces of the first color filter have bumps.